

Computer-Based Inexpensive Surface Electromyography Recording for a Student Laboratory

Demonstration of surface electromyography (EMG) to medical students in the physiology laboratory will facilitate better understanding of muscle electrophysiology and expose them to a procedure used for clinical investigation and medical research. Traditionally, demonstrating the EMG requires expensive EMG machines with data-acquisition systems. Here, we present a simple EMG display and recording system for student laboratory use that costs less than \$10 excluding the computer. The system consists of an EMG amplifier, a computer with a sound card, and custom-built software.

The EMG amplifier. The main part of the circuit is a single integrated circuit (IC) instrumentation amplifier (INA 128, Texas Instruments), with two additional components to effect high-pass filtering. The EMG signal is picked up by two silver cup electrodes (E1 and E2 in Fig. 1). The electrodes may be chloridized by immersing them in sodium hypochlorite solution (bleach) for a few seconds to form silver/silver chloride electrodes. The electrodes are connected to the IC input pins, pins 2 and 3, of INA 128. The IC is powered by two 9-V batteries connected in series, with the central common terminal being the circuit ground. The positive and negative terminals of the 9+9-V battery are connected to the respective power supply pins (pins 7 and 4) of INA 128. The circuit ground is connected to pin 5 of INA 128. Subject ground is obtained by placing an electrode over electrically inactive tissue on the subject and is connected to the circuit ground. Pins 1 and 8 determine the amplifier gain if a simple resistor is connected across. In our design, a reactive impedance, comprising a capacitor and a resistor in series, is connected between pins 1 and 8 so that a high-pass filter is also achieved in the single chip circuit. Using a resistance of 120 Ω and a capacitance of 50 μF, an amplifier gain of ~400 and a high-pass cutoff frequency of 15 Hz are obtained. It must be mentioned that the gain at 0 Hz is unity in this circuit configuration. Since a nonpolarized capacitor was not available, two 100-μF electrolytic capacitors were used in series back to back to effect a 50-μF polarity indifferent capacitor. The output from pin 6 is connected to the display device.

Recording of a EMG. The surface EMG is recorded by keeping the silver cup electrodes over the muscle belly, after subjects underwent routine skin preparation and application of electrode gel. The ground electrode is attached over a suitable electrically inactive area and the subject is asked to contract the muscle voluntarily. We have tested this system on the first dorsal interosseous and abductor digiti minimi muscles on several subjects. The active electrodes were placed ~2 cm apart (between electrode centers) on the muscle belly, and the ground electrode was placed on the back of the hand or the wrist, neither of which have any active muscles. The output from the EMG amplifier is connected to the line-in socket of the sound card of a computer. The sound card's analog-to-digital (A/D) converter is used for digitization of the signal; a sampling rate of 11,025 Hz is used in our program. The gain in the sound card can be varied using the volume control in the operating system. Sound card-based display programs can be easily written or obtained from the internet and can be used to display and record the EMG in the computer (Fig. 2). We used software written in our laboratory (written in C language with a graphical user interface for Microsoft Windows). A simple

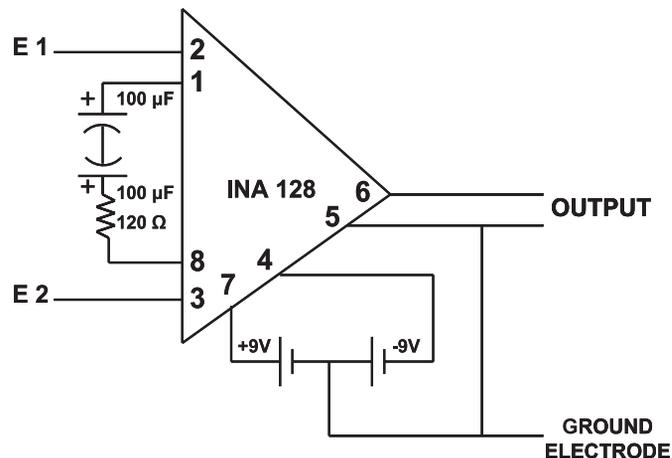


Fig. 1. Schematic diagram of the electromyographic (EMG) amplifier. E1 and E2, electrodes 1 and 2.

version of the software written in JAVA has also been created and can be used or downloaded from the research website of Christian Medical College (http://www.cmcvellore.res.in/bio/emgrec/EMG_help/EMG_help.html). Instructions for use are available at the above link. One limitation of this system could be the availability of computers for student use. The electrical safety in this system will only meet the consumer electronics safety standard complied by the computer manufacturer. This system is not meant for use in patients as it will not, in general, meet medical safety standards. The EMG amplifier is safe as it is battery operated. It is as safe as the use of headphones or microphones on the computer with wet skin. The following simple measures should be followed for optimal safety (1):

1. The computer should be periodically inspected by qualified personnel.
2. The electrical outlet to which the computer is connected should also be checked for electrical safety.

A simple alternative is to use a laptop. The above-mentioned EMG amplifier can also be used to display and record EMG signals in digital oscilloscopes and computers with other A/D converters.

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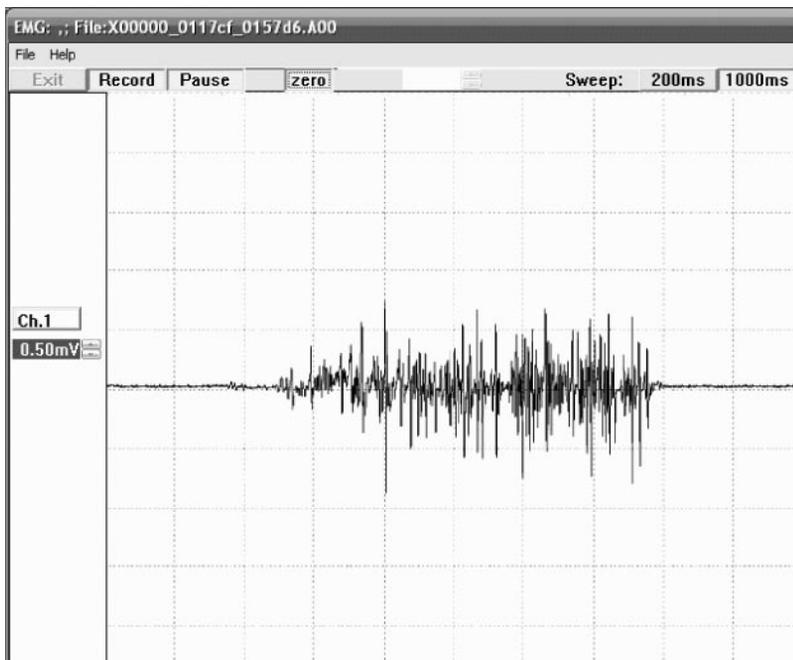


Fig. 2. Screenshot of the EMG recorded from the first dorsal interosseous muscle using a sound card. Ch.1, channel 1.

